

REMARKS/ARGUMENTS

Claims 1-15 are now active in this application.

REJECTION OF CLAIMS UNDER 35 U.S.C. § 112, SECOND PARAGRAPH

Claims 1-3, 5-7, 9-11 and 13-15 are rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. The Examiner maintains that “ohm/square” in each of the independent claims 1 and 2 is a relative term which renders the claim indefinite, and that the claims can be made definite by identifying “ohm/square μm ” or “ohm/cm”, etc.

The rejections are respectfully traversed.

The “ohm/square” means “ Ω/\square ”, as described in ,e.g., [0029] and [0030] on page 11 of the present specification and basic Japanese Patent Application No. 2000-350201 mentioned in the first page of the present specification.

The Examiner’s contention that that the claims can be made definite by identifying “ohm/square μm ” or “ohm/cm”, etc. is certainly surprising and evinces that the Examiner is unfamiliar with how surface resistivity is expressed. In this regard, the Examiner is hereby apprised that “ohm/square” (in other words, “ Ω/\square ohm/ \square ”) is very common as a unit of surface resistivity of substrate, plate, sheet, film or the like. In particular, surface resistivity is the resistance between two opposite sides of a square. It is *independent of the size of the square*. Surface resistivity is expressed in ohms per square (Ω/sq) and is traditionally used to evaluate insulative materials for electrical applications. More specifically, a person of ordinary skill in the art to which the invention pertains understands that Ohms per square *is a dimensionless square area of resistive material*, the length and width of the resistor being of equal size. Thus “X” ohm sheet resistivity material would yield an “X” ohm resistor whether

“dimension a” wide by “dimension a” long, or “dimension y” wide by “dimension y” long. If the Examiner has any doubt about what is meant by “ohm/square” with respect to resistivity, he can certainly use the words “ohms per square” in any well known Internet search engine and will likely find documents, such as those submitted with this Response, explaining what the term means.

In view of the above, it is clear that “ohm/square”, as use in claims 1 and 2, is a definite expression and that the claims recite the invention with the degree of precision and particularity required by the statute. Therefore, it is respectfully urged that the rejection be withdrawn.

REJECTION OF CLAIMS UNDER 35 U.S.C. § 103

Claims 1-15 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Yamaguchi et al. (USPN 6,407,763) in view of Shigehiro et al. (USPN 6,411,316).

The rejections are respectfully traversed.

In imposing a rejection under 35 U.S.C. §103, the Examiner is charged with the initial burden of identifying a source in the applied prior art for claim limitations. *Smiths Industries Medical Systems v. Vital Signs* 183 F.3d 1347, 51 USPQ2d 1415 (Fed. Cir. 1999). That burden has not been discharged.

With regard to surface resistivity in claims 1, 2 and 3, as noted by the Examiner, Shigehiro et al.’s surface resistivity is a resistivity of anisotropic conductive layer 34 shown in Fig. 6 of Shigehiro et al. It is not the surface resistivity of the substrate as required by claims 1, 2 and 3. More specifically, the layer 34 of Shigehiro et al. is not a substrates as recited in claims 1, 2 and 3.

The two substrates recited in independent claims 1 and 2 contact developing particles. However, the anisotropic conductive layer of Shigehiro et al. does **NOT** contact developing particles. Thus, the anisotropic conductive layer of Shigehiro et al. is completely different from the substrates required by claims 1, 2 and 3.

With regard to surface roughness of substrate recited in independent claims 4 and 8, as well as other dependent claims, as Examiner admits, Yamaguchi et al. does not disclose values of surface roughness of the substrates recited in the present claims. In fact, it is stated at column 4, lines 59-67 of Yamaguchi et al. that the surface of the substrate *may be a flat surface or a scattered surface*. This means that Yamaguchi et al. does **NOT** limit the surface roughness of the substrate to a specific value.

However, as recited in the present invention, surface roughness of the substrate is limited to a surface roughness in a specific range to form a high quality image (see Tables 3 and 4, and descriptive part relevant thereto).

In view of the above, it is clear that the Examiner has failed to establish that the specific surface resistivity and surface roughness recited in the present claims are found in the applied prior art references. Consequently, withdrawal of the rejections of claims 1-15 under 35 U.S.C. § 103 is respectfully solicited, as the Examiner has failed to discharge his burden of establishing a *prima facie* case of obviousness.

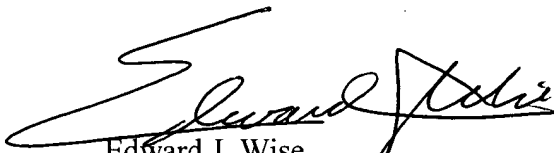
CONCLUSION

Accordingly, it is urged that the application is in condition for allowance, an indication of which is respectfully solicited. If there are any outstanding issues that might be resolved by an interview or an Examiner's amendment, Examiner is requested to call Applicants' attorney at the telephone number shown below.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

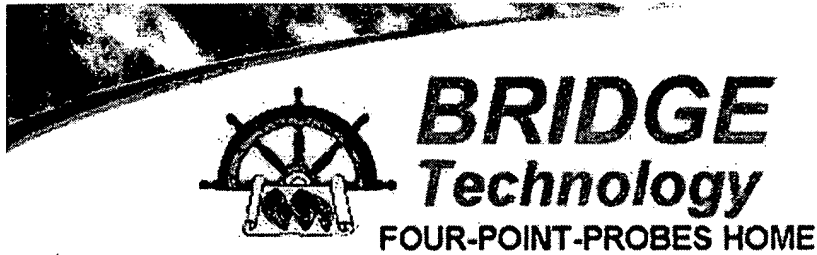
Respectfully submitted,

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Four-Point-Probes

How to Calculate Ohms-cm (volume resistivity) from Ohms-per-square (sheet resistance)

by John Clark, C. Eng, M.I.Mech.E., F.B.H.I., Managing Director of Jandel Engineering Ltd.

The term Ohms-cm (Ohms centimeter) refers to the measurement of the "bulk" or "volume" resistivity of a semi-conductive material. Ohms-cm is used for measuring the conductivity of a three dimensional material such as a silicon ingot or a thick layer of a material. The term "Ohms-per-square" is used when measuring sheet resistance, i.e., the resistance value of a thin layer of a semi-conductive material. This article briefly explains the relationship between Ohms-cm and Ohms-per-square, and how to convert from Ohms-per-square to Ohms-cm. To calculate Ohms-cm using the Jandel RM2 Test Unit, **one needs to know the thickness of the wafer** (if it is a homogeneous material) **or the thickness of the top layer that's being measured**, to be able to calculate Ohms-cm.

The equations for calculating bulk resistivity are different from those used to calculate sheet resistance, however, if one already knows the sheet resistance, bulk resistivity can be calculated by multiplying the sheet resistance in Ohms-per-square by the thickness of the material in centimeters.

Q.At what point do you stop multiplying the sheet resistance by the thickness in centimeters to arrive at Ohms-cm?

A. When the thickness exceeds 0.1 of the spacing between two needles - after which sheet resistance doesn't apply. So, 0.1mm for a probe head with 1mm needle spacings. However, due to corrections, up to 0.3mm would be ok.

If the thickness is equal or greater than five times the probe spacing, the correction factor to be applied to the formula resistivity(ρ) = $2 \times \pi \times s \times V/I$ is less than 0.1%

From the sheet resistivity point of view, the correction factor tables we have start at ratio thickness to probe spacing of 0.3, where the correction factor is unity, to a ratio of 2, where the correction factor is x0.6337. I expect these tables can be extended up to a larger ratio, but clearly from a

thickness of 2x spacing up to 5 x spacing is a bit of a no-mans land, but if one assumes that the situation is 'bulk' there are correction factors covering the ratio of thickness to spacing from 10 down to 0.4 where the correction factor is x0.288.

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What is the range of bulk resistivity (Ohms-cm) that the Jandel RM2 Test Unit can measure Ohms-cm

This crops up regularly, and it is hard to answer - let me give you an example to show the problem.

The normal range of sheet resistance which the Jandel RM2 Test Unit can measure lies between 1 and 10^7 ohms per square. The volume resistivity would be numerically equal to the sheet resistance if the specimen was 1 cm thick and made from the same material from which the sheet resistance figure was derived. It is difficult to define the limits of volume resistivity that the RTU can measure - for example we could not measure the volume resistivity of a block of platinum 1 cm thick because it is too highly conducting for the RTU to obtain a reading. If it was a platinum film 200 Angstroms thick then we could measure the sheet resistance easily and it would be approx 100 ohms per square.

Let's consider a specific wafer sample:

Let us assume that the wafer is 0.5mm thick and its resistivity is 0.005 Ohms-cm. We can set the RTU to deliver 4.5324 mA so the mV displayed is numerically equal to the sheet resistance in ohms/square. In this situation we can say that:

bulk resistivity = sheet resistance x thickness in cm.

$$\text{i.e., } 0.005 = \frac{4.5324 \times 0.05\text{cm} \times (\text{mV})}{4.5324}$$

$$= 0.005$$

$$\frac{\quad}{0.05} = 0.10\text{mV}$$

$$0.05$$

This would be the displayed reading.

Of course, if it was a thin film, the thickness would be much less than 0.5mm and the sheet resistance correspondingly more so it would be possible to calculate the bulk resistivity more accurately. It is the eternal problem of low resistivity materials, where a supplementary voltmeter able

to read a microvolt or less, is desirable. Such a voltmeter would be useful for the 0.005 Ohm-cm material -essential if it was thicker than 0.5mm.

If we were to assume that we were talking about the **bulk resistivity of silicon wafers**, then, using the formula $\rho = 2 \times \pi \times s \times V/I$ we calculate that with a probe tip spacing of 1.00mm, $V=2V$, $I=10$ nanoamperes the **MAXIMUM value of resistivity would be about 10^8 ohm.cm**. Using $V=10 \times 10^{-6}V$ and $I=10 \times 10^{-3}$ amperes the **MINIMUM value would be about 6×10^{-4} ohm.cm**. There are limitations on these values - in practice it may not be possible to drive the minimum current in the high resistivity material owing to contact resistance, and equally for the low resistivity material we are only looking at a single digit at the end of the voltage display. So we quote something a little less ambitious say 10^{-2} up to 10^6 ohms.cm.

The equation for calculating Ohms-cm **without** converting from sheet resistance is:

$$2 \times s \times \pi (\pi) \times V/I$$

Where s is the spacing between each of the four point probe tips in cm. If one uses a probe head with tip spacing of 1.591mm (62.6 mils), since 1.591mm is $1/(2 \times \pi)$ cm, it cancels out to V/I

Four-Point-Probes is a division of Bridge Technology. To request further information please call Bridge Technology at (480) 988-2256 or send e-mail to Larry Bridge at: sales@bridgetec.com

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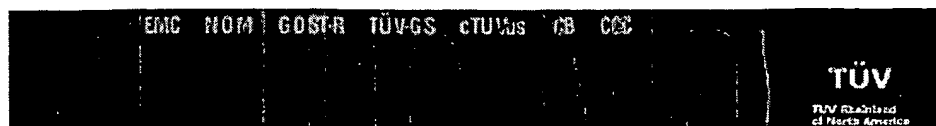
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Provided by the ESD Association

Resistance or Resistivity?



Q. What is the difference between resistance and resistivity?

A. *Resistance and resistivity* are core terms in static control. Often incorrectly used interchangeably, the terms provide us with indications of a material's static-control performance and a way to describe materials based on their resistive properties. They also serve to define the test methods used to evaluate those materials. Although the concept of surface resistance seems favored in this new century, both terms are still widely used.

Volume resistivity is defined as the ratio of the dc voltage drop per unit thickness to the amount of current per unit area passing through the material.¹ A basic material property, volume resistivity indicates how readily a material conducts electricity through the bulk of the material. Volume resistivity is expressed in ohm-centimeters ($\Omega\text{-cm}$).

Surface resistivity is a material parameter when the material is a thin film of constant thickness. *Surface resistivity* is defined as the ratio of the dc voltage drop per unit length to the surface current per unit width for electric current flowing across a surface.¹ In effect, the surface resistivity is the resistance between two opposite sides of a square. It is independent of the size of the square (as long as the size is much greater than the film thickness) or its dimensional units. Surface resistivity is expressed in ohms per square (Ω/sq) and is traditionally used to evaluate insulative materials for electrical applications.

Resistance, on the other hand, describes the opposition of a material to the flow of an electric current based on that material's shape (area and length) and its resistivity. It also indicates the degree of electrical continuity across a surface or from surface to ground. It also may indicate the ability of an object to dissipate a charge. Resistance is expressed in ohms.

Surface resistance is defined as the ratio of dc voltage to the current flowing between two electrodes of a specified configuration that contact the same side of a material. This measurement is also expressed in ohms.² It is applicable to materials regardless of construction.

Volume resistance is defined as the ratio of dc voltage to current passing between two electrodes (of a specified configuration) that contact opposite sides of the material of the object under test. Volume resistance is reported in ohms.³

It should be noted that surface resistance per ANSI/ESD STM 11.11 and volume resistance when measured in accordance with ANSI/ESD STM 11.12 are the preferred methods for evaluating and classifying static-control materials used in electronic applications. These standard test methods are the primary references employed in current ESD control program standards, e.g., ANSI/ESD S20.20.

References

1. ESD-ADV1.0, "Glossary," ESD Association, Rome, NY.
2. ESD STM 11.11-2001, "Surface Resistance Measurement of Static Dissipative Planar Materials," ESD Association, Rome, NY.
3. ANSI ESD STM 11.12, "Volume Resistance Measurement of Static Dissipative Planar Materials," American National Standards Institute, Washington, DC.

To submit your questions to the ESD Help Desk, or to browse the archives, go to <http://www.cemag.com/esdhelp.html>.